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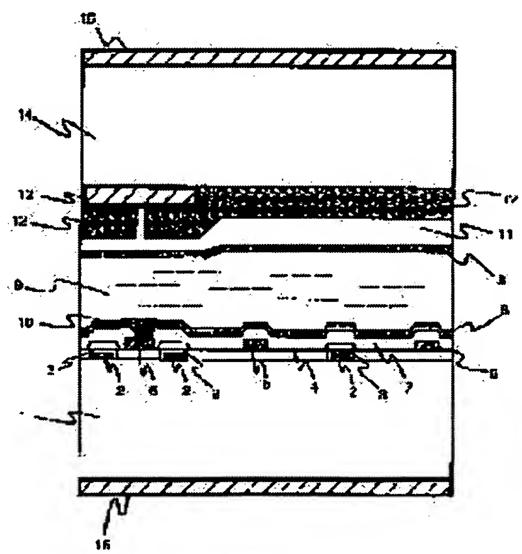
(54) ACTIVE MATRIX TYPE LIQUID CRYSTAL DISPLAY DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To suppress the degradation of liquid crystal even in the case that a defect is generated in a protective insulation film on an electrode by providing an organic material between at least one electrode in an electrode group and an alignment control layer.
SOLUTION: A TFT substrate is immersed in a polyamino resin solution together with a counter electrode and a DC voltage is applied so as to turn the electrode on the TFT substrate to a negative polarity to the counter electrode. By executing such a process, the part where the defect of an insulation film 4 or the protective insulation film 7 is generated on the electrode is covered with the electrode where the polyamino resin is formed as the organic material layer 10. Thus, even in the case that the defect of the insulation film 4 or the protective insulation film 7 is generated on the electrode, the electrode and the liquid crystal are not brought into physical contact by the organic material layer 10 formed at a defective part. As a result, the generation of ionic impurities by electro-chemical reaction is suppressed and the effect of suppressing the generation of luminance irregularities is obtained.



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(54) Title of the Invention:

ACTIVE MATRIX TYPE LIQUID CRYSTAL DISPLAY DEVICE

(57) Abstract

[Problem] To reduce uneven luminance caused in using a low driving voltage transverse electric field system active matrix type liquid crystal display device for a long time.

[Means for Resolution] In the transverse electric field system active matrix type liquid crystal display device, an organic material layer is formed between an electrode and an orientation control layer, whereby an organic material layer is formed in a defect part generated in an insulation film or a protective insulation film on the electrode to prevent the electrode and liquid crystal from coming into contact with each other. Further, an electrode formed on a dielectric substrate through the insulation film such as a signal electrode or a pixel electrode is covered with an oxide film, whereby the electrode at a positive potential with respect to a scan electrode can be prevented from coming into contact with the liquid crystal.

Claims:

1. An active matrix type liquid crystal display device, comprising: a pair of dielectric substrates, at lease one of which is transparent; a liquid crystal composition layer having dielectric anisotropy between the substrates; an orientation control layer for orientating the liquid crystal; an electrode group on the dielectric substrate, polarization means; and a driving LSI for generating a driving voltage waveform, in which a display pixel is constituted on the dielectric substrate by a scan electrode, a common electrode, a signal electrode, a pixel electrode and an active element, the electrode group on the dielectric substrate is formed on the same substrate and has a structure of mainly applying an electric field parallel to the substrate surface, characterized in that an organic material layer is provided between at least one electrode of the electrode group and the orientation control layer.

2. The active matrix type liquid crystal display device according to claim 1, wherein the organic material layer is selectively formed on the electrode part.

3. The active matrix type liquid crystal display device according to claim 2, wherein the organic material layer is polyamino resin.

4. The active matrix type liquid crystal display device according to claim 2, wherein the organic material layer is

formed by electrolytic polymerization.

5. The active matrix type liquid crystal display device according to claim 4, wherein the organic material layer is polymer taking as a raw material monomer at least one kind of a five-membered heterocyclic compound, an aromatic hydrocarbon, an aromatic amine and cyclic ether.

6. The active matrix type liquid crystal display device according to claim 5, wherein the organic material layer is a polymer taking as a raw material monomer at least one of pyrrole, thiophene, furan, indole, benzene, naphthalene, anthracene, aniline, phenol, tetrahydrofuran and derivatives thereof.

7. The active matrix type liquid crystal display device according to claim 4, wherein the organic material layer is a polymer taking a vinyl compound as a raw material monomer.

8. The active matrix type liquid crystal display device according to claim 7, wherein the vinyl compound is acrylonitrile, methacrylonitrile, methylacrylate, methylmethacrylate, butadiene, styrene, isoprene, α-methylstyrene or derivatives thereof.

9. The active matrix type liquid crystal display device according to claims 1 to 8, wherein the organic material layer is an organic insulation film.

10. The active matrix type liquid crystal display device according to claims 1 to 9, wherein a protective insulation film formed of an inorganic material is provided between the

electrode group and the orientation control layer, and a part of the protective insulation film is formed by the organic material layer.

11. A manufacturing method for the active matrix type liquid crystal display device according to claims 2 to 10, wherein the method includes a process of immersing the substrate where the electrode group is formed in a resin solution or the monomer solution, and applying voltage to the electrode group.

12. An active matrix type liquid crystal display device comprising: a pair of dielectric substrates, at lease one of which is transparent; a liquid crystal composition layer having dielectric anisotropy between the substrates; an orientation control layer for orientating the liquid crystal; an electrode group on the dielectric substrate, polarization means; and a driving LSI for generating a driving voltage waveform, in which a display pixel is constituted on the dielectric substrate by a scan electrode, a common electrode, a signal electrode, a pixel electrode and an active element, the electrode group on the dielectric substrate is formed on the same substrate and has a structure of mainly applying an electric field parallel to the substrate surface, characterized in that an electrode formed on the surface on the liquid crystal composition layer side of the scan electrode through an insulation layer is covered with an oxide film.

13. The active matrix type liquid crystal display device

according to claim 12, wherein the oxide film is a self-oxidation film of the electrode.

14. The active matrix type liquid crystal display device according to claim 12, wherein the oxide film is a conductive oxide film.

15. The active matrix type liquid crystal display device according to claims 12 to 14, wherein the electrode contains at least one kind of Al, Ta, Nb, Mo, Cr, Ti and Cu.

16. The active matrix type liquid crystal display device according to claims 12 to 15, wherein the electrode is a signal electrode.

17. The active matrix type liquid crystal display device according to claims 12 to 16, wherein the oxide film is formed by anodizing process.

18. The active matrix type liquid crystal display device according to claims 1 to 10, and 12 to 16, wherein at least one kind of compound having a cyano group is contained in the liquid crystal composition layer.

Detailed Description of the Invention:

[0001]

[Technical Field to which the Invention Belongs]

This invention relates to a liquid crystal display device and particularly to the active matrix type liquid crystal display device adapted to drive the liquid crystal using a thin film

transistor (TFT).

[0002]

[Prior Art]

In the active matrix type liquid crystal display device, as electrodes for driving a liquid crystal layer, opposed transparent electrodes formed on two substrates, respectively, have been used heretofore. This case adopts a twisted nematic (TN) system in which the operation is performed by making the direction of an electric field applied to the liquid crystal substantially vertical to the substrate surface. On the other hand, a transverse electric field system in which the direction of an electric field applied to the liquid crystal is made substantially parallel to the substrate surface to remarkably enlarge the angle of visibility has been proposed by JP-B-63-21907, USP4345249, WO91/10936, JP-A-6-222397 and JP-A-6-160878 and so on, and it has been put to practical use. In these active matrix type liquid crystal display devices, normally, in order to prevent the metal electrode on the substrate from directly coming into contact with the liquid crystal, an insulation film or a protective insulation film formed of an inorganic material has been formed of silicon nitride or the like on the electrode. In these insulation films, sometimes a defect such as a pinhole due to deposition failure of silicon nitride or etching failure is caused in its manufacturing process. When the liquid crystal display device

having such a defect is used for a long time, uneven luminance is caused on the display surface because of the following reason. When a defect such as a pinhole is caused in the insulation film or the protective insulation film covering the electrode, the liquid crystal and the metal electrode directly come into contact with each other at that defective part. In this case, a scan electrode is kept at negative potential of 10 V or more with respect to the other electrodes during almost all period except a small selection period when a thin film transistor turns on. Consequently, when the liquid crystal display device is driven for a long time, constantly a DC voltage of 10 V or higher is applied through the liquid crystal layer to the scan electrode and the other electrodes, so the electro-chemical reaction is gradually caused to generate the ionic impurities. As a result, the ion concentration in the liquid crystal is increased in the vicinity of the defective part, or the generated ions adsorb on an orientation film, resulting in local lowering of effective driving voltage applied to the liquid crystal to cause uneven luminance. As a method for reducing uneven luminance caused by direct contact between the liquid crystal and the metal electrode in the transverse electric field system, JP-A-10-206857 proposes a method for restraining the occurrence of defect in the protective insulation film by regulating the relationship between the height of the electrode and the film thickness of the protective insulation film on the TFT substrate,

the shape of the electrode, and the protective insulation film material.

[0003]

[Problems that the Invention is to Solve]

Although the publicly known art adopting the above transverse electric field system has proposed a method for restraining the occurrence of a crack-like protective insulation film defect due to an electrode stepped structure on the substrate, it has the problem that it is impossible to restrain defect of the protective insulation film due to deposition failure of silicon nitride or etching failure.

[0004]

Further the conventional transverse electric field system has the problem that when the liquid crystal and the metal electrode directly come into contact with each other due to defect caused in the insulation film and the protective insulation film on the electrode, uneven luminance is especially remarkably caused as compared with the longitudinal electric field system. Since the direction of electric field for driving the liquid crystal is the in-plane direction of the substrate in the transverse electric field system, diffusion from a generation source of impurity ions to a pixel area is accelerated. Further, since the thickness of the liquid crystal layer in the transverse electric field system is smaller as compared that in the longitudinal electric field system, the volume of

the liquid crystal layer per pixel is small so that the ion concentration of the liquid crystal layer becomes higher as compared with that in the longitudinal electric field system even with the generation of impurity ions of the same quantity. Further, since the capacity of the liquid crystal layer is about 1/10 as large as that in the longitudinal electric field system, lowering of the effective voltage applied to the liquid crystal layer in the case of increased ion concentration of the liquid crystal layer is larger than that in the longitudinal electric field system. These factors remarkably cause uneven luminance in the transverse electric field system more than in the longitudinal electric field system.

[0005]

On the other hand, in the conventional transverse electric field system liquid crystal display device, the insulating protective film of silicon nitride has been formed thick on the electrode in order to restrain the above uneven luminance. This arrangement can decrease the number of defectives of silicon nitride caused by deposition failure or etching failure, but encountered is the problem that the driving voltage increases because the distance between the electrode and the liquid crystal layer becomes longer in the transverse electric field system. That is, the transverse electric field system has the problem that high liquid crystal driving voltage is needed to restrain uneven luminance caused in the case of a long time use.

[0006]

The invention has been made to solve the problems and it is an object of the invention to provide a high image quality, wide angle of visibility and low driving voltage active matrix type liquid crystal display device, which may prevent uneven luminance even in a long-time drive by restraining contact between an electrode and liquid crystal even in the case where defect is caused in a protective insulation film on the electrode.

[0007]

[Means for Solving the Problems]

In order to achieve the above object, according to the invention, an active matrix type liquid crystal display device includes a pair of dielectric substrates, at lease one of which is transparent, a liquid crystal composition layer having dielectric anisotropy between the substrates, an orientation control layer for orientating the liquid crystal, an electrode group on the dielectric substrate, polarization means, and a driving LSI for generating a driving voltage waveform, wherein an organic material layer is provided between at least one electrode of the electrode group and the orientation control layer.

[0008]

According to the above means, even in the case where defect is caused in a protective insulation film and an insulation

film, the metal electrode can be prevented from coming into contact with the liquid crystal. When the organic material layer is formed between the electrode and the orientation control layer, even in the case of defect is caused in the insulation film or the insulating protective film, the defect part is filled with the organic material layer, whereby the contact between the electrode and the liquid crystal at the defect part can be prevented so as to restrain the generation of ionic impurities due to electro-chemical reaction. At the time, the organic material layer between the electrodes for applying voltage to the liquid crystal is removed so that the organic material layer is selectively formed on the electrode part, whereby the interval between the liquid crystal layer and the electrode between the electrodes is small so that the voltage applied between the electrodes is effectively applied to the liquid crystal layer to produce the effect of restraining a rise of driving voltage. Accordingly, even if the protective insulation film on the electrode is made thinner, the generation of impurity ions can be restrained to restrain uneven luminance and reduce the driving voltage at the same time.

[0009]

When the organic material layer is selectively formed on a part where defect of the insulating protective film or the insulation film is caused on the electrode, the organic material layer is not formed on the electrode outside the defect

part of the insulating protective film or the insulation film so as to obtain the effect of further reducing the driving voltage. As the organic material layer of this type, polyamino resin can be used. Since the polyamino resin can be deposited by the electrodeposition process, deposition is selectively performed on the defect part where the electrode is exposed by voltage application in the resin solution. In the electrodeposition process, a substrate where defect is caused in the protective insulation film or the insulation film is immersed with a counter electrode in the resin solution, and DC voltage is applied between the electrode on the substrate and the counter electrode. At the time, an electric current flows through a part where the defect of the protective insulation film is caused on the electrode, polymer in the resin solution is deposited on the part where the defect of the protective insulation film is caused on the electrode, and the defect part on the electrode is selectively covered with the polymer. Further, as a method for selectively forming an organic material layer on a part where the defect of the insulating protective film or the insulation film is caused on the electrode, an electrolytic polymerization method can be used. In the electrolytic polymerization method, a substrate where defect is caused in the protective insulation film or the insulation film is immersed with a counter electrode in a raw material monomer solution, and DC voltage is applied

between the electrode on the substrate and the counter electrode. At the time, at a part where the defect of the protective insulation film is caused on the electrode, electrolytic polymerization occurs so that polymer is selectively formed on the electrode of the defect part to cover the electrode. The polymer formed by the electrolytic polymerization is generated by polymerization of a monomer with a small molecular weight on the electrode to form a dense film. Further, since the generation of gas is not caused in polymerization of monomer on the electrode, bubbles are not generated in the defect part of the insulation film or the protective insulation film so as to form a dense organic film.

[0010]

The organic material is polymer taking as a raw material monomer at least one kind from a five-membered heterocyclic compound, an aromatic hydrocarbon, an aromatic amine and cyclic ether, so that an organic material can be suitably formed on the electrode with positive polarity by electrolytic polymerization.

[0011]

The organic material is polymer taking as raw material monomer at least one of pyrrole, thiophene, furan, indole, benzene, naphthalene, anthracene, aniline, phenol, tetrahydrofuran and derivatives thereof. Since the organic material is polymer taking a vinyl compound as a raw material

monomer, the organic material can be suitably formed on the electrode with negative polarity by electrolytic polymerization.

[0012]

The vinyl compound is acrylonitrile, methacrylonitrile, methylacrylate, methylmethacrylate, butadiene, styrene, isoprene, α-methylstyrene or derivatives thereof.

[0013]

As the organic material is an insulator, the liquid crystal and the electrode are surely insulated, resulting in a large effect of restraining deterioration of liquid crystal due to electro-chemical reaction.

[0014]

Further, at least one kind of compounds having a cyano group is contained in the liquid crystal composition, so that the driving voltage can be reduced, and although the impedance of the liquid crystal composition is lowered, the occurrence of uneven luminance can be restrained.

[0015]

On the other hand, the inventors have found that when the liquid crystal and the electrode come into contact with each other to cause electro-chemical reaction, the metal electrode is liable to dissolve on the electrode side relatively at the positive potential. When the electrode such as a signal electrode formed on the scan electrode through the insulation

film is covered with an oxide film, even if defect is caused in the insulation film or the insulating protective film, the metal electrode at positive potential by 10 V or more with respect to the scan electrode does not come into contact with the liquid crystal, so that dissolution of the metal electrode can be restrained. Since the dissolution of the metal electrode generates ionic impurities, which is the cause of uneven luminance, the above means for restraining the dissolution of the metal electrode can restrain the generation of ionic impurities, which causes uneven luminance. Further, the oxide film covering the electrode is formed so that the protective film on the electrode has a multi-layer structure to remarkably lower the probability of causing the defect of the oxide film and the defect of the protective insulation film in the same place. Therefore, even if the film thickness of the protective insulation film is made smaller than that of the oxide film, it is possible to obtain the effect of restraining the generation of impurity ions, which is the cause of uneven luminance, so that restraint on uneven luminance and reduction of driving voltage are enabled at the same time.

[0016]

According to the invention, even in the case where defect of the protective insulation film or the insulation film is caused on the electrode, the metal electrode can be prevented from coming into contact with the liquid crystal, so that

restraint on uneven luminance and reduction of driving voltage due to thinning of the protective insulation film are enabled at the same time.

[0017]

[Mode for Carrying Out the Invention]

The invention will now be described by the embodiments. The embodiments are illustrations of the invention, and they will not limit the scope of the invention.

[0018]

(Embodiment 1)

Fig. 1 shows a part of the section of a pixel in an active matrix type liquid crystal display device according to the invention. In Fig. 1, the reference numeral 1 is a first dielectric substrate, 2 a common electrode, 3 a self-oxidation film, 4 an insulation film, 5 a pixel electrode, 6 a signal electrode, 7 a protective insulation film, 8 an orientation film, 9 a liquid crystal layer, 10 an organic material layer, 11 an overcoat film, 12 a color filter, 13 a black matrix, 14 a second dielectric substrate, and 15 a sheet polarizer. In the active matrix type liquid crystal display device of the invention, an electric field parallel to the surface of the first dielectric substrate 1 is generated between the common electrode 2 and the pixel electrode 5, and the liquid crystal molecules in the liquid crystal layer 9 are rotated in the direction parallel to the surface of the first dielectric

substrate 1 to display an image.

[0019]

The concrete configuration of the embodiments will now be described. A group of various electrodes, an insulation film for preventing short-circuiting, a thin film transistor, and a protective insulation film for protecting the thin film transistor and the electrode group are formed on the first dielectric substrate to constitute a TFT substrate.

[0020]

Fig. 2 is a plan view showing one pixel on the TFT substrate and its periphery. The sectional structure showing a part of the pixel of the liquid crystal display device shown in Fig. 1 corresponds to the part taken along cutting plane line A - A'. As shown in Fig. 2, the respective pixels are disposed in an intersecting area of a scan electrode 16 and a common voltage signal line 17 and two adjacent signal electrodes 6 (an area surrounded by four signal conductors). Each pixel includes a thin film transistor 18, a storage capacity 19, a pixel electrode 5 and a common electrode 2. The scan electrode 16 and the common voltage signal line 17 are extended in the lateral direction and two or more common voltage signal lines are disposed in the vertical direction in the drawing. The signal electrode 6 is extended in the vertical direction, and two or more signal electrodes are disposed in the lateral direction. The pixel electrode 5 is connected to the thin film

transistor 18, and the common electrode 2 is integrated with the common voltage signal line 17. The pixel electrode 5 and the common electrode 2 are opposite to each other to be comb-teeth shaped, and they are electrodes respectively elongated in the vertical direction in the drawing.

[0021]

Fig. 3 is a diagram showing the section of the thin film transistor 18 in the cutting plane line B - B′ of Fig. 2. The thin film transistor 18 has a gate electrode also serving as the scan electrode 16, the insulation film 4, an i-type semiconductor layer 20, a source electrode also serving as the pixel electrode 5 and formed integrally, and a drain electrode also serving as the signal electrode 6 and formed integrally.

[0022]

The common electrode 2 and the scan electrode 16 are formed by patterning aluminum (Al). Further, the self-oxidation film 3 formed by anodizing is formed on the common electrode 2 and the scan electrode 16. A part intersecting the signal electrode 6 is narrowed to lower the probability of short-circuiting in a space up to the signal electrode 6, and further forked so that in the case of short-circuiting, separation can be done by laser trimming.

[0023]

An insulation film is formed of silicon nitride on the common electrode and the scan electrode 16, and in the present

embodiment, the film thickness is about 0.24 μm.

[0024]

The i-type semiconductor layer 20 is formed of amorphous silicon 0.2 μm. In order to reduce short-circuiting in the intersecting part of the scan electrode 16 and the signal electrode 6 and in the intersecting part of the common voltage signal line 17 and the signal electrode 6, the i-type semiconductor layer 20 is formed on these intersecting parts as well.

[0025]

An N(+) type amorphous silicon semiconductor layer 21 doped with phosphorus (P) is formed for ohmic contact on the surface of the i-type semiconductor layer 20 between the source electrode, the drain electrode and the i-type semiconductor layer 20.

[0026]

The signal electrode 6 and the pixel electrode 5 are formed by patterning chrome (Cr).

[0027]

The protective insulation film 7 with a thickness of 0.3 μm is formed of silicon nitride on the thin film transistor 18, the signal electrode 6 and the pixel electrode 5.

[0028]

In the insulation film 4 and the protective insulation film 7, in the manufacturing process thereof, sometimes defect

such as a pinhole is caused by deposition failure of silicon nitride or etching failure. When such defect is caused in the insulation film 4 or the protective insulation film 7, the electrodes such as the scan electrode 16 and the signal electrode 6 come into contact with the liquid crystal, so that the generation of impurity ions due to electro-chemical reaction is accelerated to cause uneven luminance. Then, the TFT substrate is immersed with the counter electrode in polyamino resin solution, and a DC voltage of 20V is applied so that the electrode on the TFT substrate has negative polarity with respect to the counter electrode. By performing such a process, the polyamino resin is formed as the organic material layer 10 on the part where the defect in the insulation film 4 or the protective insulation film 7 is formed on the electrode to cover the electrode.

[0029]

According to the present embodiment, even if the defect of the insulation film 4 or the protective insulation film 7 is caused on the electrode, the electrode and the liquid crystal are prevented from physically coming into contact with each other by the organic material layer 10 formed in the defect part. As a result, the generation of ionic impurities due to electro-chemical reaction can be restrained so as to produce the effect of restraining the occurrence of uneven luminance.

[0030]

Fig. 4 is a diagram showing a color filter substrate constituted by sequentially forming a black matrix 13, a color filter 12, an overcoat film 11 on the dielectric substrate in Fig. 2. For the black matrix 13, material obtained by mixing carbon or an organic pigment in resist material is used. The color filter 12 is constituted with stripes by repetition of red, blue and green. For the color filter 12, material obtained by dispersing a pigment in acrylic resin or the like is used. The overcoat film 11 is formed of a transparent resin material such as acrylic resin or epoxy resin.

[0031]

Polyimide with a film thickness of about 80 nm is formed as the orientation film 8 on the protective insulation film 7 of the TFT substrate and on the overcoat film 11 of the color filter substrate, and the surface thereof is subjected to rubbing to orientate the liquid crystal. The rubbing directions in the upper and lower substrates are parallel to each other, and the angle made between the rubbing direction and the direction of applying an electric field is 75°. The liquid crystal layer is constituted between the TFT substrate and the color filter substrate, and the surfaces of both substrates where the orientation film is formed are in contact with the liquid crystal layer. Polymer beads as a spacer for keeping constant the thickness (a gap) of the liquid crystal layer are dispersed between the TFT substrate and the color filter substrate, and

the liquid crystal layer between both substrates is sealed with a sealing material to surround the display area. As the sealing material, epoxy resin, for example, is used.

[0032]

As the liquid crystal material LC, used is nematic liquid crystal whose dielectric constant anisotropy $\Delta\varepsilon$ is positive, its value being 7.3, and whose refractive-index anisotropy Δn is 0.074 (589nm, 2°C). The thickness (gap) of the liquid crystal layer is controlled to be 4.0 μm by the polymer beads dispersed between the upper and lower substrates.

[0033]

The sheet polarizer 15 is so constructed that the polarized light transmission axis of the sheet polarizer 15 on the TFT substrate is aligned with the rubbing direction, and the polarized light transmission axis of the sheet polarizer 15 on the color filter substrate is made to intersect perpendicularly thereto. By this configuration, it is possible to obtain a liquid crystal panel having a normally close characteristic that with an increase in voltage (voltage between the pixel electrode 5 and the common electrode 2) applied to the pixel of the invention, the transmittance rises.

[0034]

Fig. 5 is a diagram showing the wire connection of an equivalent circuit of the display matrix part and its peripheral circuit. Although this is a circuit diagram, it is drawn

corresponding to the actual geometrical arrangement. The reference numeral 22 is a matrix array in which a plurality of pixels are arranged in two dimensions. In the drawing, the reference sign X designates a signal electrode 6, and suffix letters G, B and R are added corresponding to green, blue and red pixels, respectively. The reference sign Y designates a scan electrode 16, and suffix numerals and letter 1, 2, 3 ... end are added according to the order of scan timing. The scan electrode Y (suffix letters are omitted) is connected to a vertical scanning circuit 23, and the signal electrode X (suffix letters are omitted) is connected to a video signal driving circuit 24. The reference numeral 25 is a power supply circuit for obtaining a plurality of divided and stabilized voltage sources from one voltage source, which may include a circuit for interchanging the information for CRT (cathode ray tube) from a host (a hot processor) with the information for the TFT liquid crystal display device and a circuit for driving the common voltage signal line 17.

[0035]

Fig. 6 is an exploded perspective view showing the respective components of a liquid crystal display module 26. The reference numeral 27 is a frame-like shield case (a metal frame) formed by a metallic plate, the reference numeral 28 a display window thereof, 29 a liquid crystal display panel, 30 a video signal driving circuit board, 31 a scan signal driving

circuit board, 32 a power supply circuit board, 33 a flat cable electrically connecting the driving circuit boards, 34 an optical diffuser, 35 a light guiding element, 36 a reflector, 37 a backlight fluorescent tube, 38 a backlight case, and 39 an inverter circuit. The respective members are stacked to have the vertical arrangement relationship as shown in the drawing to construct a module MDL.

[0036]

The module 26 is fixed wholly with a claw and a hook mounted on the shield case 27. The backlight case 38 is shaped to store the backlight fluorescent tube 37, the optical diffuser 34, the light guiding element 35, and the reflector 36, and the light of the backlight fluorescent tube 37 disposed on the side of the light guiding element 35 is made into uniform backlight on the display screen by the light guiding element 35, the reflector 36 and the optical diffuser 34 and emitted to the liquid crystal display panel 29 side. The inverter circuit board 39 is connected to the backlight fluorescent tube 37 to serve as a power supply for the backlight fluorescent tube 37.

[0037]

The active matrix type liquid crystal display device of the present embodiment retains a wide angle of visibility so that while the contrast ratio of 10 or more is maintained at an angle of 160° or more up and down and right and left, gradation inversion is not caused, and display failure due to uneven

luminance is not caused even in 100 consecutive days' use.

[0038]

(Comparative Example 1)

This comparative example has the same configuration as the embodiment 1 except the following.

[0039]

After a protective insulation film is formed, an orientation film is formed without performing an electrodeposition process. Consequently, in the present comparative example, an organic material layer 10 is not formed in the defect part of the insulation film or the protective insulation film, so that the electrode comes into contact with the liquid crystal through the orientation film.

[0040]

Although the thus obtained active matrix type liquid crystal display device has a wide angle of visibility so that while the contrast ratio of 10 or more is maintained at an angle of 160° or more up and down and right and left, uneven luminance was frequently caused after 10 consecutive days' use. This is considered to result from that deposition of the orientation film in the defect part is poor to lower the insulation effect of the orientation film so that the electrode and the liquid crystal can't be thoroughly insulated from each other at the defect part having a stepped structure.

[0041]

(Comparative Example 2)

The present comparative example has the same configuration as the comparative example 1 except the following.

[0042]

The film thickness of the protective insulation film 7 formed of silicon nitride is 0.9 μm.

[0043]

Although the active matrix type liquid crystal device of the present embodiment retains a wide angle of visibility so that while the contrast ratio of 10 or more is maintained at an angle of 160° or more up and down and right and left, the gradation inversion is not caused, and display failure due to uneven luminance is not caused even in 100 consecutive days' use, the driving voltage was increased by 0.7 V as compared with that in the embodiment 1. In here, however, the signal voltage at which the transmittance of the liquid crystal panel becomes maximum is taken as the driving voltage. As a result, the liquid crystal layer can't be driven enough by the output voltage from the video signal driving circuit or the like, so that the luminance of display is lowered.

[0044]

[Embodiment 2]

The present embodiment has the same configuration as the embodiment 1 except the following, and in the present embodiment, an organic material layer 10 is formed by electrolytic

polymerization.

[0045]

A common electrode, a scan electrode 16, a signal electrode 6 and a pixel electrode are formed of platinum (Pt). After a protective insulation film is formed, a TFT substrate is immersed with a counter electrode in an aniline solution where tetraethylammonium tetrafluoroborate is dissolved instead of polyamino resin solution, and a DC voltage of 3.5 V is applied so that the electrode on the TFT substrate is polarized to be positive with respect to the counter electrode. By performing such a process, electrolytic polymerization is caused at the part where the defect of the insulation film or the protective insulation film is caused on the electrode so that polyaniline is densely formed as the organic material layer 10.

[0046]

Since the polymer formed by electrolytic polymerization is generated by polymerization of a monomer with a small molecular weight on the electrode, a dense film is formed. In the electrodeposition process, in the case where the defect of the protective insulation film is fine, gas generated by electrolysis of water when the polymer molecule is deposited on the electrode is accumulated as bubbles in the fine defect part, so that the contact between the polymer solution and the electrode can be obstructed not to form an insulation film in some case. In the electrolytic polymerization process, however,

when the monomer is polymerized on the electrode, no gas is generated not to produce bubbles in the defect part, so that even in the case where the defect of the protective insulation film is too fine to form an electrodeposition film, a dense organic film can be formed on the defect part. As a result, an insulation effect enough to restrain the contact between the liquid crystal and the electrode can be obtained. Accordingly, the generation of ionic impurity due to electro-chemical reaction can be restrained so as to obtain the effect of restraining the occurrence of uneven luminance.

[0047]

According to the present embodiment, even if the defect of the insulation film or the protective insulation film is caused on the electrode, the electrode and the liquid crystal can be prevented from physically coming into contact by the dense organic material layer formed on the defect part. Further, since the insulating orientation film is formed after the defect part is filled with the organic material layer 10, the insulating effect produced by the orientation film is not lowered even in the defect part. Accordingly, even in the case where the organic material layer 10 is a semiconductor film such as polyaniline, the deterioration of liquid crystal due to the electro-chemical reaction can be restrained by the physical shielding effect of the organic material layer 10 and the insulating effect of the orientation film so as to produce the

effect of restraining uneven luminance. Although polyaniline, which is aromatic amine, is used as an organic material layer in the present embodiment, it is not necessary that the organic material layer is especially limited to this material if a dense film is formed of the material on the electrode of positive polarity by electrolytic polymerization. As this type of organic materials, cited are five-membered heterocyclic compounds such as poly pyrrol, polythiophene, and polyfuran, aromatic hydrocarbons such as poly-p-phenylene and polynaphthalin, aromatic compounds such as polyazulene, polyindole, and poly-p-phenylene oxide, and copolymers containing at least one kind from raw material monomers of the above polymers or its derivatives. Cyclic ether such as tetrahydrofuran may be used as a raw material monomer.

[0048]

The active matrix type liquid crystal display device of the present embodiment retains a wide angle of visibility so that while the contrast ratio of 10 or more is maintained at an angle of 160° or more up and down and right and left, the gradation inversion is not caused, and display failure due to uneven luminance is not caused even in 100 consecutive days' use.

[0049]

(Comparative Example 3)

The present comparative example has the same

configuration as the embodiment 2 except the following.

[0050]

As a common electrode 2 and a scan electrode 16, Al is used, and as a signal electrode 66 and a pixel electrode 5, Cr is used. Further, a self-oxidation film 3 is formed on the common electrode 2 and the scan electrode 16 by anodizing to improve the insulating reliability in the parts intersecting a signal electrode 66. In the thus obtained active matrix type liquid crystal display device, a number of line defect or bit defect are caused. The reason for this is that since the Al and Cr used as electrode material have lower oxidation reduction potential than aniline, which is raw material monomer of an organic material layer, the aniline is not oxidized, but a metal electrode is oxidized and dissolved to cause breaking of wire in the electrolytic polymerization process. Accordingly, in the case of forming an electrolytic polymerized film with a TFT substrate of positive polarity, it is necessary to use a raw material monomer having lower oxidation reduction potential than the metal (Al in the present comparative example) having the lowest oxidation reduction potential of the electrode materials on the TFT substrate. In this specification, it is assumed that in the electrolytic polymerization process taking the TFT substrate of positive polarity, in the case of the voltage condition that an organic material layer is formed without dissolution of the metal electrode, the oxidation reduction

potential of the raw material monomer is lower than the oxidation reduction potential of an electrode having the lowest oxidation reduction potential of the electrode group on the TFT substrate.

[0051]

(Embodiment 3)

The present embodiment has the same configuration as the comparative example 3 except the following.

[0052]

A TFT substrate is immersed with a counter electrode in a methylmethacrylate solution obtained by dissolving methyl methacrylate in acetonitrile instead of the aniline solution, and a DC voltage of 20 V is applied so that an electrode on the TFT substrate is polarized to be negative with respect to the counter electrode. By performing such a process, electrolytic polymerization is caused at a part where defect of an insulation film or a protective insulation film is caused on an electrode so that polymethyl methacrylate is densely formed as an organic material layer 10. As a result, even if the defect of the insulation film or the protective insulation film is caused on the electrode, the electrode and the liquid crystal can be prevented from coming into contact with each other by the dense organic material layer formed on the defect part, so that the deterioration of the liquid crystal is restrained so as to produce the effect of restraining uneven luminance. Further, according to the present embodiment, the organic

material layer formed on the defect part is an insulation film, so the liquid crystal and the electrode can be surely insulated from each other to produce a large effect of restraining the generation of ionic impurities due to electro-chemical reaction.

[0053]

Although polymethyl methacrylate is used as the organic material layer in the present embodiment, it is not necessary that the organic material layer is especially limited to this material if a dense film is formed of the material on the electrode of positive polarity by electrolytic polymerization. As the organic materials of this type, cited are vinyl compounds such as polyacrylonitrile, polymethacrylonitrile, polymethylacrylate, polybutadiene, polystyrene, polyisoprene, polymethylstyrene, and copolymers containing at least one kind selected from the raw material monomers of the above or derivatives thereof. In the case of forming the electrolytic polymerized film with the TFT substrate of negative polarity as shown in the present embodiment, it will be sufficient that the raw material monomer is easily reduced more than the electrode most easily reduced of the group of various kinds of electrodes. In this specification, it is assumed that in the electrolytic polymerization process taking the TFT substrate of negative polarity, in the case of the voltage condition that an organic material layer is formed without

reduction of the electrode, the raw material monomer is more easily reduced than the electrode most easily reduced of the electrode group on the TFT substrate.

[0054]

The active matrix type liquid crystal display device of the present embodiment retains a wide angle of visibility so that while the contrast ratio of 10 or more is maintained at an angle of 160° or more up and down and right and left, the gradation inversion is not caused, and display failure due to uneven luminance is not caused even in 100 consecutive days' use.

[0055]

(Embodiment 4)

The present embodiment has the same configuration as the embodiment 3 except the following.

[0056]

5 wt.% of 4-(4-cyano-3, 5-difluorophenyl) Pentyl cyclohexane is added as a liquid crystal compound having a cyano group to nematic liquid crystal composition held between a TFT substrate and a counter electrode.

[0057]

Although the liquid crystal compound having a cyano group is effective for reducing the driving voltage, it has the problem that the impedance of the liquid crystal layer is liable to drop. Accordingly, when an electrode and the liquid crystal

come into contact with each other, the generation of ionic impurities due to electro-chemical reaction is accelerated. The active matrix type liquid crystal display device of the present embodiment, however, retains a wide angle of visibility so that while the contrast ratio of 10 or more is maintained at an angle of 160° or more up and down and right and left, the gradation inversion is not caused, and display failure due to uneven luminance is not caused even in 100 consecutive days' use. As described above, even in the case of using the liquid crystal compound lowering the impedance of the liquid crystal layer such as the liquid crystal compound having a cyano group, the effect of the organic material layer formed on the defect part of the insulation film and the protective insulation film is high enough to obtain an image of high image quality not causing uneven luminance.

[0058]

(Comparative Example 4)

The present comparative example has the same configuration as the embodiment 4 except the following.

[0059]

After a protective insulation film is formed, an orientation film is formed without an electrolytic polymerization process. Consequently, in the present comparative example, an organic material layer is not formed on the defect part of an insulation film and a protective

insulation film, so an electrode comes into contact with liquid crystal through the orientation film.

[0060]

While the thus obtained active matrix type liquid crystal display device retains a wide angle of visibility so that while the contrast ratio of 10 or more is maintained at an angle of 160° or more up and down and right and left, and the gradation inversion is not caused, uneven luminance is frequently caused in two consecutive days' use. This is considered to result from that deposition of the orientation film in the defect part is poor to lower the insulation effect of the orientation film so that the electrode and the liquid crystal can't be insulated from each other thoroughly in the defect part having a stepped structure. The reason why uneven luminance is caused in a shorter-term's use as compared with the comparative example 1 having the same configuration except the liquid crystal composition is that the impedance of the liquid crystal layer is lowered due to the use of the liquid crystal compound having a cyano group to accelerate the generation of ionic impurities due to electro-chemical reaction in the defect part.

[0061]

(Embodiment 5)

Fig. 7 shows a part of the section of a pixel in an active matrix type liquid crystal display device according to the present embodiment. The present embodiment has the same

configuration as the comparative example 4 except that an organic insulation film is formed as an organic material layer 10 on a protective insulation film on an electrode. As the organic insulation film, for example, acrylic resin, epoxy resin, polyimide and the like are used, and the organic insulation film between a pixel electrode 5 and a common electrode 2 is removed by photolithography technique. As described above, the organic insulation film is not formed in an opening part between the pixel electrode 5 and the common electrode 2, whereby a liquid crystal layer and the electrode are kept close to each other in the opening part so as to obtain the effect of restraining a rise in driving voltage and also produce the effect of restraining uneven luminance because the electrode and the liquid crystal are prevented from coming into contact with each other by the organic insulation film even in the case where the defect of the insulation film or the protective insulation film is caused on the electrode.

[0062]

The active matrix type liquid crystal display device of the present embodiment retains a wide angle of visibility so that while the contrast ratio of 10 or more is maintained at an angle of 160° or more up and down and right and left, gradation inversion is not caused, and display failure due to uneven luminance is not caused even in 100 consecutive days' use.

[0063]

(Embodiment 6)

Fig. 8 shows a part of the section of a pixel in an active matrix type liquid crystal display device according to the present embodiment. The present embodiment has the same configuration as the comparative example 4 except that an electrode protective film 40 is formed 0.3 μm of silicon oxide on a signal electrode 6 to cover the signal electrode 6, and a protective insulation film 7 is formed 0.3 μm thereon of silicon nitride. In this configuration, even in the case where comparatively large defect as much as several μm is caused in the protective insulation film 7 due to deposition failure of silicon nitride or etching failure, there is low possibility of causing the defect of an electrode protective film 40 in the same place, so the signal electrode 6 can be effectively prevented from coming into contact with the liquid crystal. Further, in the intersecting part of the signal electrode 6 and a scan electrode 16, the signal electrode 6 is very close to the scan electrode 16, and the signal electrode 6 is at the positive potential higher by 10 V or more with respect to the scan electrode 16. Accordingly, when defect is caused in the protective insulation film 7 and the insulation film 4 in the intersecting part so that the signal electrode 6 and the scan electrode 16 are exposed to the liquid crystal, dissolution of the signal electrode 6 due to electro-chemical reaction is remarkably caused. Accordingly, the generation of ionic

impurities due to electro-chemical reaction can be remarkably restrained by covering the signal electrode 6 having a number of parts intersecting the scan electrode 16 with the electrode protective film 40.

[0064]

The thus obtained active matrix type liquid crystal display device retains a wide angle of visibility so that while the contrast ratio of 10 or more is maintained at an angle of 160° or more up and down and right and left, gradation inversion is not caused, and display failure due to uneven luminance is not caused even in 100 consecutive days' use.

[0065]

(Embodiment 7)

Fig. 9 shows a part of the section of a pixel in an active matrix type liquid crystal display device according to the present embodiment. The present embodiment has the same configuration as the embodiment 6 except that an electrode protective film 40 is formed 0.3 μm of silicon oxide to cover a signal electrode 6 and a pixel electrode 5.

[0066]

Since the pixel electrode 5 has no part overlapping a scan electrode 16 except a thin film transistor element 18 part, the pixel electrode is harder to dissolve due to electro-chemical reaction as compared with the signal electrode 6, but the potential is higher by 10 V or more with respect to the scan

electrode 16. Accordingly, the pixel electrode 5 is covered with the electrode protective film 40 to thereby more heighten the effect of preventing the electrode polarized to be positive with respect to the scan electrode 16 in the defect part of a protective insulation film 7 from coming into contact with liquid crystal.

[0067]

The thus obtained active matrix type liquid crystal display device retains a wide angle of visibility so that while the contrast ratio of 10 or more is maintained at an angle of 160° or more up and down and right and left, gradation inversion is not caused, and display failure due to uneven luminance is not caused even in 100 consecutive days' use.

[0068]

(Comparative Example 5)

The present embodiment has the same configuration as the embodiment 7 except the following.

[0069]

A protective insulation film of silicon nitride is formed with a film thickness of 0.6 μm without forming an electrode protective film of silicon oxide.

[0070]

Although the active matrix type liquid crystal display device of the present embodiment retains a wide angle of visibility so that while the contrast ratio of 10 or more is

maintained at an angle of 160° or more up and down and right and left, and gradation inversion is not caused, uneven luminance is caused in several parts in 10 consecutive days' use. This is considered to result from that a no-defect protective insulation film can't be formed by silicon nitride with a film thickness of 0.6 μm.

[0071]

(Comparative Example 6)

The present embodiment has the same configuration as the comparative example 5 except the following.

[0072]

The film thickness of a protective insulation film 7 formed of silicon nitride is set to 0.9 μm.

[0073]

Although an active matrix type liquid crystal display device of the present embodiment retains a wide angle of visibility so that while the contrast ratio of 10 or more is maintained at an angle of 160° or more up and down and right and left, gradation inversion is not caused, and display failure due to uneven luminance is not caused even in 100 consecutive days' use, the driving voltage is increased by 0.4 V as compared with that in the embodiment 7 by an increase in thickness of the protective insulation film. Provided that in here the signal voltage at which the transmittance of a liquid crystal panel becomes maximum is taken as the driving voltage. As a

result, with the output voltage from a video signal driving circuit, a liquid crystal layer can't be driven thoroughly so that the luminance of display is lowered.

[0074]

(Embodiment 8)

The present embodiment has the same configuration as the embodiment 7 except the following.

[0075]

An electrode protective film 40 covering the upper sides of a signal electrode 6 and a pixel electrode 5 is a self-oxidation film formed by anodizing. Further, Al, Ta, Nb, Mo, Ti, Cu or alloy thereof is used for the signal electrode 6 and the pixel electrode 5, and the self-oxidation film may be used as an electrode protective film 40. By this configuration, plasma CVD process for forming silicon nitride requiring high vacuum is not needed so as to improve the productivity.

[0076]

The thus obtained active matrix type liquid crystal display device retains a wide angle of visibility so that while the contrast ratio of 10 or more is maintained at an angle of 160° or more up and down and right and left, the gradation inversion is not caused, and display failure due to uneven luminance is not caused even in 100 consecutive days' use.

[0077]

(Embodiment 9)

The present embodiment has the same configuration as the embodiment 7 except the following.

[0078]

An electrode protective film 40 covering the upper sides of a signal electrode 6 and a pixel electrode 5 is formed of ITO. It is found that by this configuration, the electrode protective film 40 is provided with both a function of protecting an inside metal electrode and a function as an electrode. As a result, the part of the electrode protective film is also functioned as an electrode, whereby wiring resistance can be reduced. Further, since the pixel electrode 5 comes closer to a liquid crystal layer 9 for the thickness of the electrode protective film 40, a voltage drop caused between the electrode and the liquid crystal layer 9 is decreased so that the driving signal voltage for driving the liquid crystal is effectively applied to the liquid crystal layer 9 to reduce the driving voltage by 0.2 V. Provided that in here, the signal voltage at which the transmittance becomes maximum is taken as the driving voltage.

[0079]

The reason why the conductive oxide film has both the function of protecting the metal electrode and the function as the electrode is considered as follows. The signal electrode 6 and the pixel electrode 5 are at positive potential with respect to the scan electrode 16 almost all the time except

a very small selective period of time when the TFT turns on. Accordingly, dissolution of the signal electrode 6 and the pixel electrode 5 due to ionization is caused by oxidative reaction. The already oxidized conductive oxide such as ITO is hard to oxidize more than this, so it is functioned as the electrode protective film for the signal electrode 6 and the pixel electrode 5. Further, in the case where a common electrode 2 is formed on the upper layer of the scan electrode 16 through an insulation layer, it may be used as the electrode protective film 40 for the common electrode 2. Further, conductive oxide films such as indium oxide, tin oxide and titanium oxide may be used for the electrode protective film 40 instead of ITO. Further, the pixel electrode 5 and the common electrode 2 may be formed by the conductive oxide film to be also served as the electrode protective film, and in that case, it will be sufficient that an inorganic film such as a protective insulation film is not formed on the electrode such as the pixel electrode 5 or the common electrode 2.

[0080]

The thus obtained active matrix type liquid crystal display device retains a wide angle of visibility so that while the contrast ratio of 10 or more is maintained at an angle of 160° or more up and down and right and left, gradation inversion is not caused, and display failure due to uneven luminance is not caused even in 100 consecutive days' use.

[0081]

[Advantage of the Invention]

According to the invention, as described above, in the transverse electric field system active matrix type liquid crystal display device, the organic material layer is formed between the electrode and the orientation control layer, or the electrodes formed on the dielectric substrate through the insulation film, for example, the signal electrode and the pixel electrode are respectively covered with the oxide film, to thereby obtain the liquid crystal display device which may have high image quality not causing uneven luminance, wide angle of visibility and low driving voltage.

Brief Description of the Drawings:

Fig. 1 is a diagram showing a part of the section in a unit pixel in a liquid crystal display device of the invention;

Fig. 2 is a diagram showing a typical example of an electrode structure of one pixel and its periphery in the liquid crystal display device of the invention;

Fig. 3 is a sectional view of a thin film transistor element in the liquid crystal display device of the invention;

Fig. 4 is a diagram showing a typical example of a color filter substrate in the liquid crystal display device of the invention;

Fig. 5 is a circuit diagram including a matrix part and

its periphery of the liquid crystal display device of the invention;

Fig. 6 is an exploded perspective view of a liquid crystal module in the liquid crystal display device of the invention;

Fig. 7 is a diagram showing a part of the section in a unit pixel in a fifth embodiment of a liquid crystal display device according to the invention;

Fig. 8 is a diagram showing a part of the section in a unit pixel in a sixth embodiment of a liquid crystal display device according to the invention; and

Fig. 9 is a diagram showing a part of the section in a unit pixel in a seventh embodiment of a liquid crystal display device according to the invention.

[Description of the Reference Numerals and Signs]

1: first dielectric substrate 2: common electrode 3: self-oxidation film 4: insulation film 5: pixel electrode 6: signal electrode 7: protective insulation film 8: orientation film 9: liquid crystal layer 10: organic material layer 11: overcoat film 12: color filter 13: black matrix 14: second dielectric substrate 15: sheet polarizer 16: scan electrode 17: common voltage signal line 18: thin film transistor 19: storage capacity 20: i-type semiconductor layer 21: N(+) type amorphous silicon semiconductor layer 22: matrix array where a plurality of pixels are arranged in two dimensions 23: vertical scanning circuit 24: video signal

driving circuit 25: power supply circuit 26: liquid crystal display module 27: shield case 28: display window 29: liquid crystal display panel 30: video signal driving circuit board 31: scan signal driving circuit board 32: power supply circuit board 33: flat cable 34: optical diffuser 35: light guide element 36: reflector 37: backlight fluorescent tube 38: backlight case 39: inverter circuit board 40: electrode protective film